Proposed Small Arms Marking Pilot

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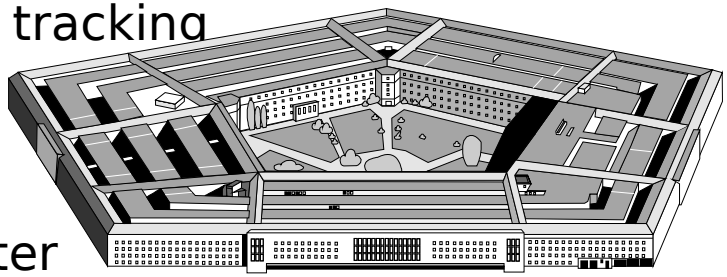
Donald L. Roxby – (256) 830-8123

RVSI Symbology Research Center

Pentagon Objectives

- Identify the most appropriate marking technique for small arms marking

- Demonstrate automated tracking at Anniston Army Deport
  - Facilitate the automation of weapons tracking
  - Eliminate manual data entry
  - Improve data accuracy
  - Speed data entry
  - Link weapon to use history in computer

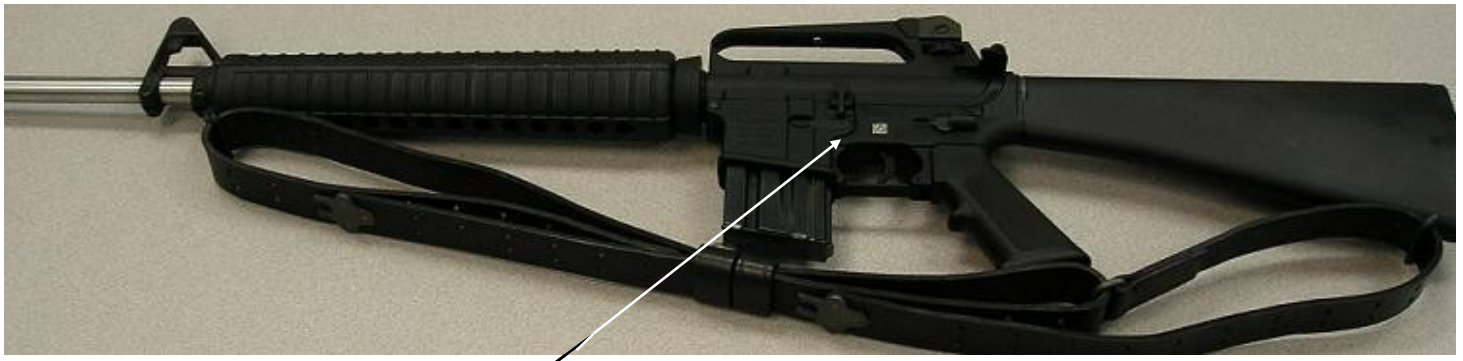


- Establish cost per mark (including computer system updates)
  - Needed to test the feasibility of utilizing performance based logistics (PBL)
  future UID marking programs

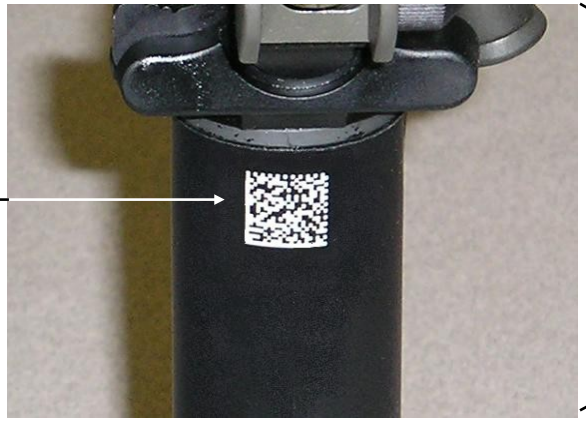
Weapon Identification Requirements

- Marking must be UID compliant (Data Matrix symbol)
- The marking shall remain decodable throughout the functional life of the weapon (approximately 25 years)
- The marking shall withstand all environmental conditions that the weapon will be exposed to under normal and war time conditions, including refurbishment processes.
- The presence of the marking or the method of marking shall not have a detrimental affect on functional, performance, reliability, or durability of the weapon
- Symbol markings applied to weapons shall be placed in close proximity to existing human-readable markings
- Weapons shall be marked in arms rooms (mobile marker) and refurbishment centers (fixed station marker)

Proposed Marking Locations for M16 Rifle



Permanent Laser Colored Mark



Laser Etched, Tamper Resistant Label For Reading Weapon While Racked

Proposed Marking Location for M9 Pistol

Permanent Laser Colored Mark

Laser Etched, Tamper Resistant Label For Reading Weapon While Racked

History

- **U.S.A.F, Robbins AFB, 1989 -** Established that markings could be applied to small arms using laser-marking technology. Tests indicated that laser marking applied to anodized aluminum coating had no adverse affects on substrate material properties. MIL-STD-130 revised to include laser marking of anodized aluminum.

- **National Aeronautics and Space Administration (NASA), Marshall Space Flight Center (MSFC), Alabama, 1990 –** Established Compressed Symbology Testing (CST) Laboratory to assist industry with the development of a new two-dimensional symbol for direct part marking. NASA expands upon U.S.A.F. test program and successfully applies 2-D symbols to over 70 different materials. Lab personnel created readable 2-D symbols markings using 40 different marking methods. Material tests confirm that direct laser markings can be safely applied metallic materials (with the exception of bare aluminum and titanium) with negligible effect on material properties

History Continued

Rockwell International Corporation, Huntsville, Alabama, 1993 - MIL-STD-130J revised to permit the implementation of two-dimensional (2-D) symbols onto government programs.

- **Rockwell International Corporation, Huntsville, Alabama, 1993 -** Hand held readers became available and were tested at Fort Lee, Virginia. Readers failed to read 2-D symbols applied to weapons under low light conditions and were not able to read small code.

- **Automated Identification Manufacturers Association (AIM), 1994** – Releases symbology standard for Data Matrix symbol.

- **American National Standards Institute (ANSI), 1995** – Standardizes Symbologies across all industries.
  - Data Matrix to be used to identify individual parts

History Continued

- **RVSI Symbology Research Center (SRC), Huntsville, Alabama, 1998 -** Advanced readers developed and successfully tested in Arms Room applications. Identifying a 13 clear coat that might withstand small arms operational conditions. Conducted preliminary tests at the University of Tennessee Space Institute. Identified three candidates for subsequent U.S. Army tests.

- **U.S. Army Armament Research and Development Center (AMSTA-AR-ESW-S) at Rock Island, Illinois, 1998 –** Conducted additional tests on clear coats identified by the SRC and certified one for use during the Proposed Fort Lewis Weapons Marking Pilot Project. Selected coating (984) conforms to Military Specification MIL-I-46058-C, Type AR, ER and UR (QPL#576-90) and meets "NSA" hydrolytic stability (reversion) requirements. DYMAX 984 passes UL-94 Flammability rating.

- **RVSI Symbology Research Center (SRC), 1998 –** Search conducted to

History Continued

- **RVSI Symbology Research Center (SRC), 2003** – Tests confirm that CO2 laser can discolor weapon coatings with out breaking corrosion protection seal … thereby eliminating the need for a clear coat over the mark.

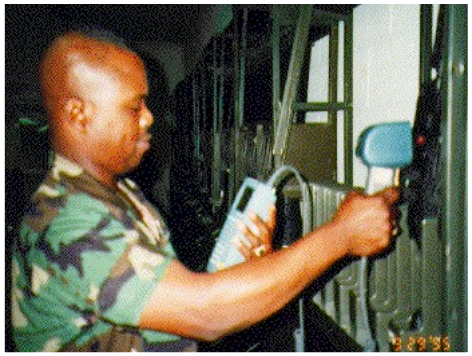
- **RVSI Symbology Research Center (SRC), 2004** – Managed program to develop a mobile marking card and head-held Nd:YAG laser under National Center for Manufacturing Sciences (NCSM)/DoD.

- **RVSI Symbology Research Center (SRC), 2005** – Working with Front Range Laser to develop a hand-held CO2 laser for use in UID legacy marking applications.

Proposed Approach

Marking program to be conducted in phases

- Phase I - Requirements Study
- Phase II – Test, Setup and Demonstrate Syste
- Phase III – Initial Operations



Phase I - Requirements Study
Funded BY RVSI

Test Plan

- Establish data format
- Establish data size
- Evaluate small arms use and overhaul environments
- Evaluate marking processes And select optimal Method
- Mark samples and conduct reading tests
- Study existing tracking system and establish number of input stations
- Make recommendations based on tests, interviews and system evaluations.

Requirements Study

- Visited Anniston, to evaluate existing refurbishment and overhaul processes
  - **Bldg 129 – Small Arms Shop,** evaluated current tracking and overhaul processes.
  - **Bldg 114 – Metal Plating Shop,** evaluated finish stripping and re-plating processes.
  - **Bldg 145 – Machine Shop,** evaluated alternative marking process capabilities
- Discussed how small arms are currently processed and tracked
- Obtained samples to test laser coloring process
- Generated presentation containing recommended small arms marking and reading processes
- Develop phase II proposal for small arms marking and reading system for Anniston

Small Arms Options

Small Arms Types Processed at Anniston

- *M-9 9mm Pistol
- M-16 5.56mm Rifle
- M-60 7.62mm Machine Gun
- M240G Medium Machine Gun
- M2 .50 Caliber [12.7mm] Machine Gun
- M134 5.56mm Mini Gun
- Others

* Weapon selected for evaluation under Phase I (high volume & used by multiple government agencies.)

Beretta M9 Pistol Selected for Pilot

- Beretta M9 pistol selected because is has broad use across multiple organizational lines. Solution offers more bang for the buck!!

  - Over half a million M9 handguns have been delivered to the Army, Navy, Air Force, Marines and Coast Guard.

  - Weapon also used by US Immigration and Naturalization Service, US Postal Service and many major law enforcement organization, such as the LA Police Department, LA sheriff's Office and Maryland, Ohio and Pennsylvania State Police.

9mm Pistol Receiver Specifications

- Receiver Material: Light aluminum alloy (7075-T6). Anodized in a sulfuric acid bath, making the hardness and durability equal to steel.
- Receiver Thickness: 0.101-inch
- Coating: Hard Anodize (Bruntom)
- Surface Color: Non-glare, corrosion-resistant, black matte finish
- Current Marking Depth (Steel Stamp): ?-inch

Note: Beretta only makes one frame style for each caliber, so all 9mm 92-series guns (FS, G, D, brigadier, etc.) use the same frames.

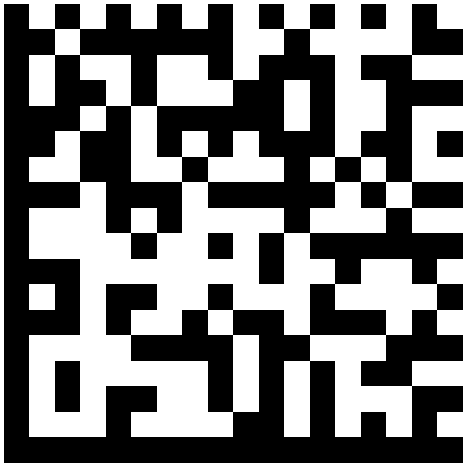
M-9 Overhaul

M-9 Overhaul Processes:

1) Degreased & Cleaned with trichloroethylene at 195 degrees
2) Steel Shot (S70 grade)
3) Chromic Acid Strip
4) Steel Shot (S70 grade)
5) Alkaline Cleaner
6) Water Rinse
7) Desmutter
8) Plating (anodize)
9) Water Rinse
10) Dye
11) Sealer

Marking Format/Size

- Weapon Type: M9 Pistol
- Available Marking Area: 0.371-inch square
- Data Format: Construct 2
- Data content:
  [)>$^{R}_{S}$06$^{G}_{S}$17V8T257$^{G}_{S}$1PM9$^{G}_{S}$S1234567$^{R}_{S}{}^{E}$o$_{T}$
- Symbol Matrix Size: 22x22
- Data Cell Size: 0.0136-inch
- Overall Symbol Size: 0.30-inch



Marking Process Evaluation

Process	Pros	Cons
Dot Peen	Deep Marks, Fast Marking, Should Survive Overhaul	Part Must Be Clamped, Size Limitation, Reading Issues After Plating, May Deform Receiver
Machine Scribing or Engraving	Deep Marks, Should Survive Overhaul	Part Must Be Clamped, Slow Marking Process, Reading Issues After Plating
Laser Engraving	Small Size, High Fidelity Mark, Deep Marks, Fast Marking, Should Survive Overhaul	Reading Issues After Plating
Laser Bonding	Small Size, High Fidelity Mark	Multi-step Process, May Not Survive Overhaul, Reading Issues After Plating
Laser Discoloration	Small Size, High Fidelity Mark, Fast Marking	Will Not Survive Overhaul

Marking Process Selection

Laser marking selected as optimum solution.

- No special fixtures required, fast, high resolution, no consumables, easy to use,
  long life and require very little maintenance.

- Laser engraving will survive overhaul and is best solution for small arms
  marking, but is not approved for use and will require additional testing.

- Laser discoloration is approved for use and can be implemented immediately,
  but will not survive overhaul and will need to be reapplied after part is anodized
  at Anniston.

- Multiple laser types will work.

Laser Wavelengths Evaluated

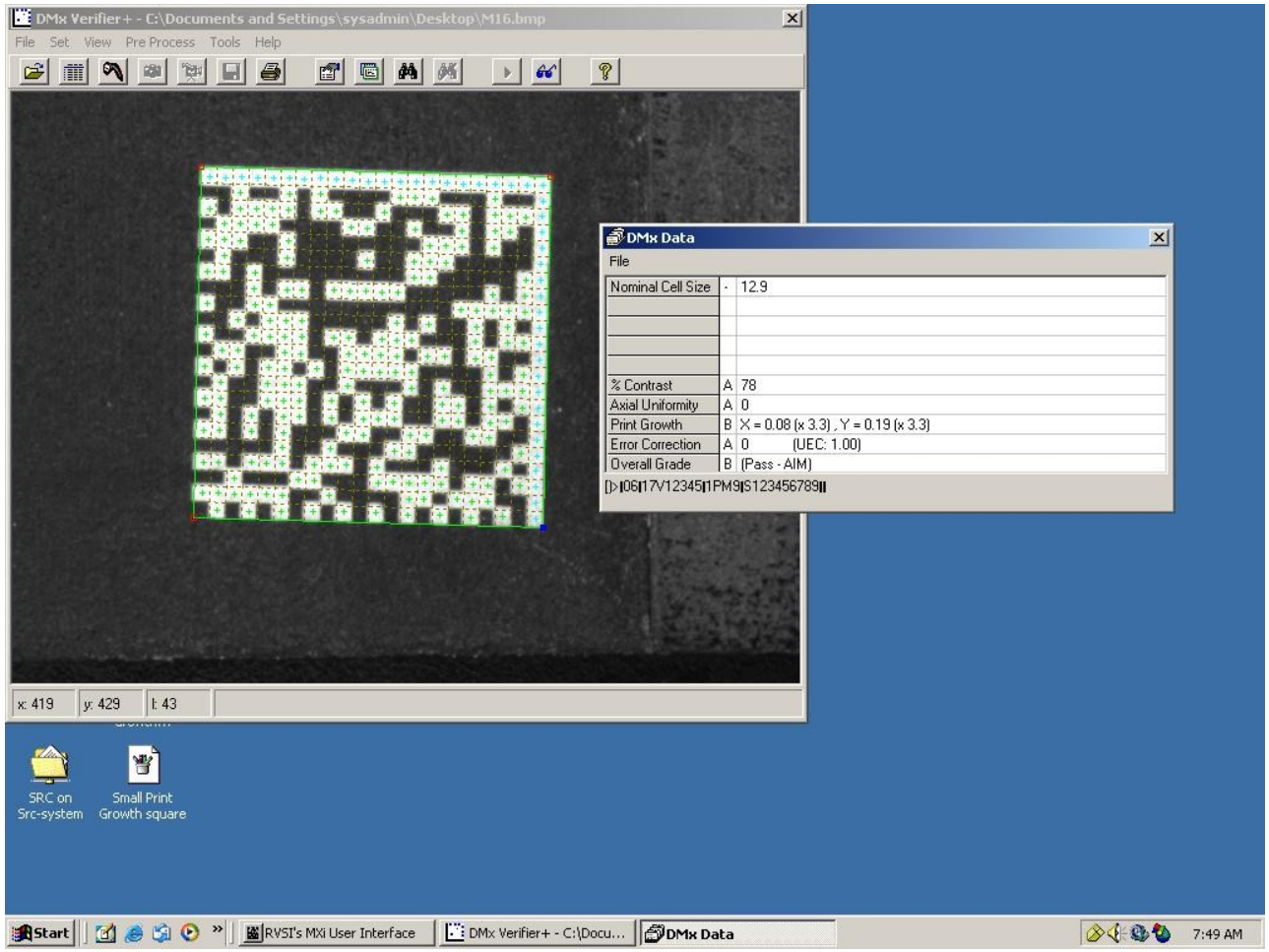
Laser Type	Light Amplifier	Wavelength (nm)	Remarks
Nd:YLF	Diode-pumped Neodymium Yttrium Lithium Fluoride Crystal	1047	Higher maintenance than Nd:YAG; has ability to break anodized seal and melt metal (safety issue)
Nd:YAG	Diode-pumped Neodymium Doped Yttrium Aluminum Garnet Crystal	1064	Able to break anodized seal and melt metal (safety issue); High Cost
Nd:YVO_4	Diode-pumped Neodymium Doped Yttrium Vanadate Crystal	1064	Able to break anodized seal and melt metal (safety issue); High Cost
Ytterbium Fiber to Fiber	Diode-pumped Ytterbium Fiber	1600	Able to break anodized seal and melt metal (safety issue); High Cost
CO2	CO2 Gas	10,000	Lowest cost, low power laser, will not break anodize seal

Laser Type Selected

CO2 Laser Selected

- Lowest cost laser
- Wavelength provides fewest safety issues
- Laser beam turns black dye in surface finish white
- No corrosion issues - anodize coating not penetrated
- Application approved for use by MIL-STD-130 and NASA-STD-6002
- UID marking (0.30-inch square) can be applied to M9 pistol in 2.10 seconds
- Marker very versatile and can used for many other applications

Example Of Proposed Small Arms Marking



Phase I Conclusions

The team is ready to proceed with Phase II

- Marking Process has been selected
- Further testing required to certify use of deep laser engraving
- Need to define numbers of input stations and types of data to be uploaded
- Required equipment has been identified
- Manpower is available
- RVSI and Anniston are prepared to take the next step
- Awaiting PM approval to proceed

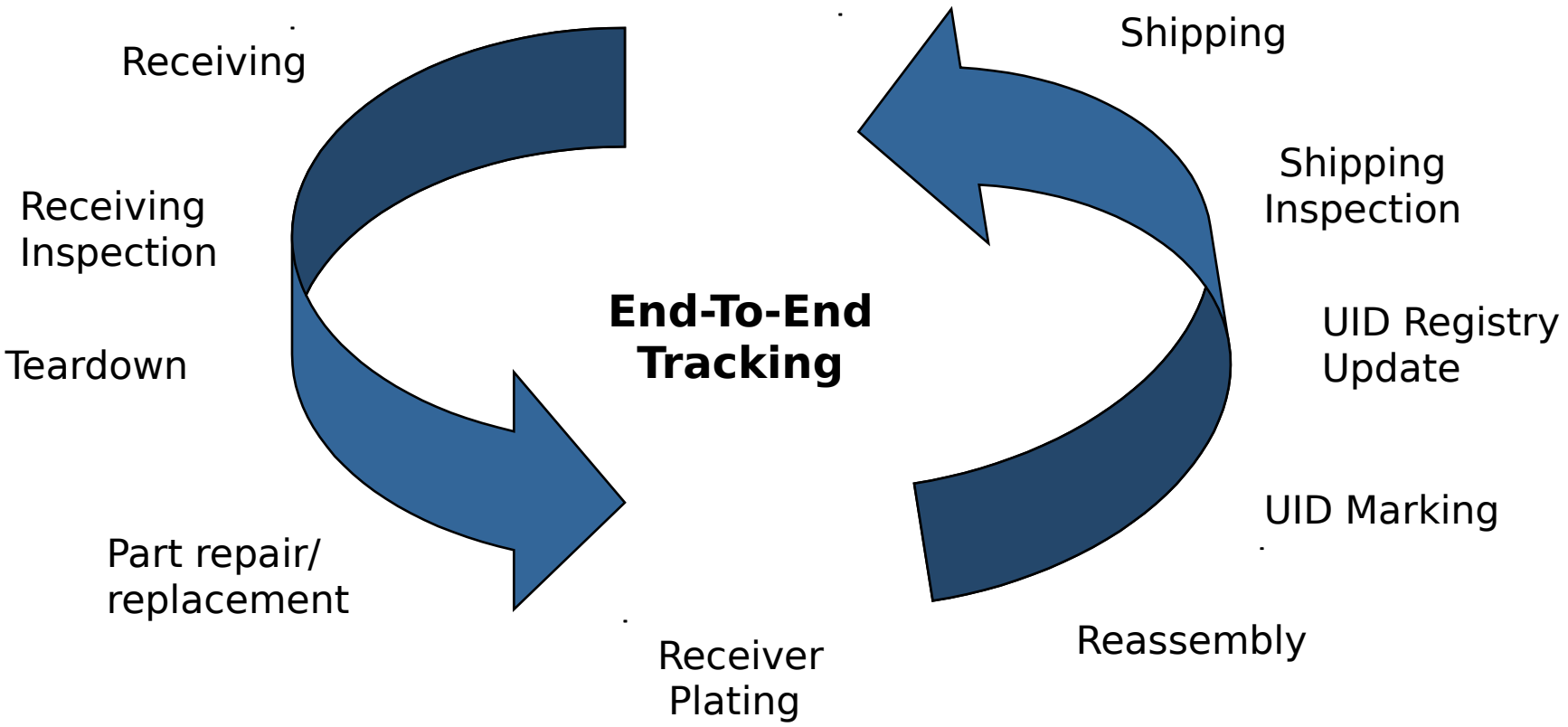
Phase II – Set-up, Test, and Demonstrate System

Phase II – System Test and Demonstration

- Build up a fixed marking station with fixtures for M9 Pistols
- Acquire and ship appropriate marking, reading, and verification and communication equipment to Anniston
- Set-up hardware at appropriate positions
- Test/debug hardware/host computer interface
- Begin Phase II marking operations
- Test and certify use of deep laser engraving (new process)

- Develop average marking, reading, verification, and registry input times
- Establish initial cost per weapon based on Phase II study
- Generate final report

Establish Data Input Points



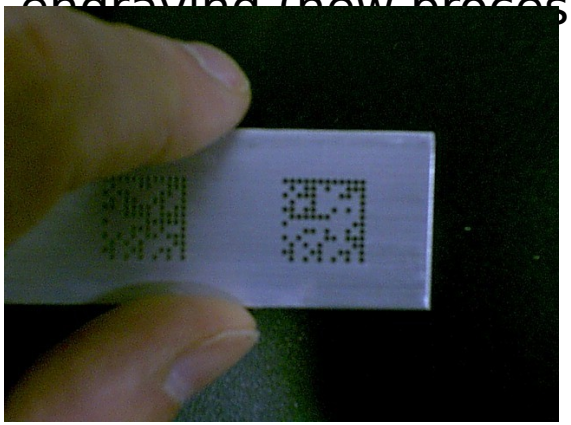
Hardware Needed to Support Phase II

The RVSI team will provide all equipment necessary to mark the weapons, verify mark quality and to pass information to a new small arms data base.

- Monode fixed station, 30 watt CO2 laser
- RVSI UID Compliance Kit (CK) for checking and mark quality verification
- RVSI HE40's for readers at each data input station
- RVSI MX Wedge Software to link readers to existing computers (emulate keyboard)
- Data system update and storage - TBD

Small Arms Marking Process

- Initiate Phase II marking using Laser Coloring (approved marking process)
- Conduct study to determine feasibility of marking small arms using deep laser
  engraving (new process that w

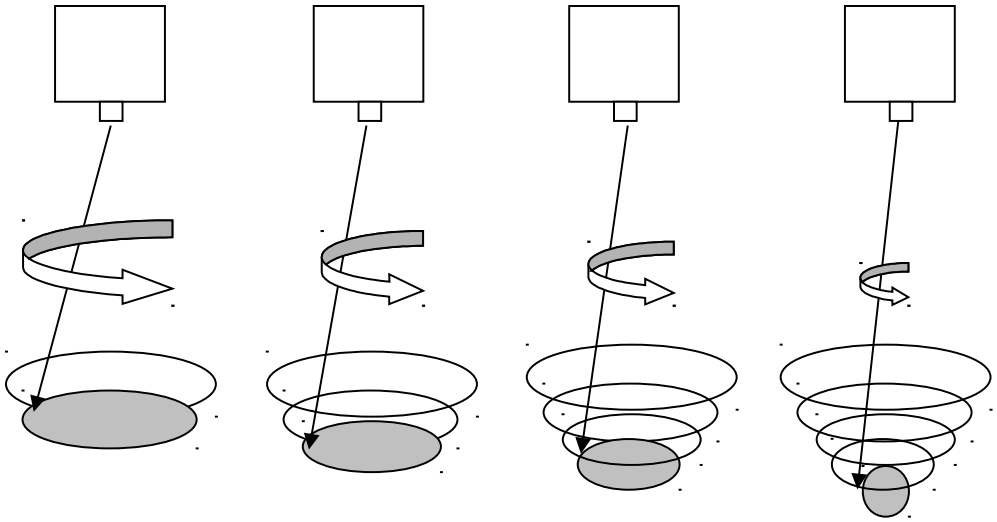


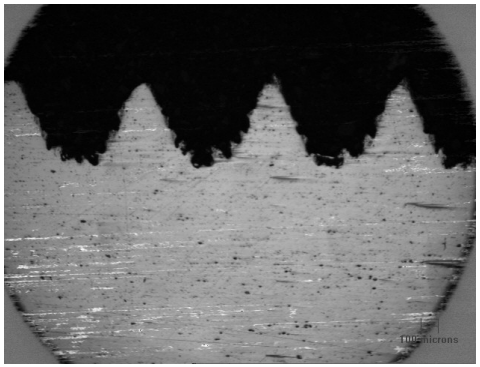
Deep Laser Engraved Marking

USAF Marking Test Coupon – Machine and Laser Engraved Marks Survive Overhaul And Remain Readable

Deep Laser Engraving Process

The process can be adapted to apply Data Matrix symbols using a Nd:YAG laser configured for deep laser engraving to cut a representation of the symbol directly into the lower receiver. The laser program can be adjusted to product symbols of varying sizes and to any depth required. It can also cut data cells with shapes reflect light away from the reader lens, creating the artificial contrast required for successful reading





SEM Cross Section Of Laser Engraved Marking

Laser Engraving Test Plan

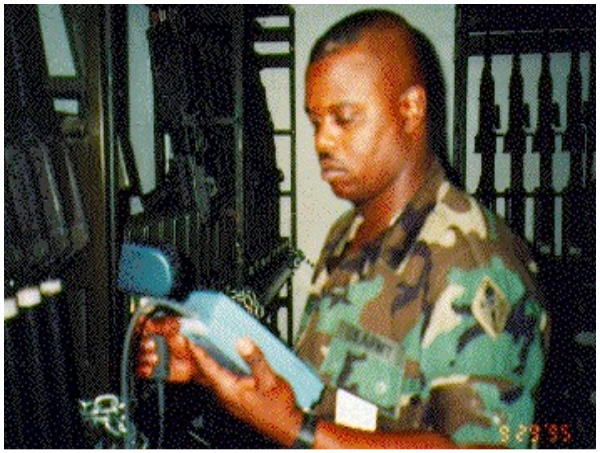
- Acquire Samples of AL 7075 T-6
- Apply deep laser engraved markings of varying depths and shapes (not more then 10 percent of receiver thickness)
- Submit samples to Anniston to send through overhaul/plating process
- Monitor marking readability as samples pass through overhaul processes
- Submit test results and samples to Rock Island Arsenal for evaluation/ approval
- Revise MIL-STD 130 to include new process

Note: Will required a reader upgrade at each station

Phase III – Initial Operations

Phase III – Pre-Production System Operations (6 Months)

- Mark weapons either before or after overhaul – based on Phase II findings.
- Read and conduct mark quality verification
- Ensure appropriate data entry protocols are followed
- Update holding database for subsequent UID registry transfer (not part of this phas
- Government will lease all required equipm



Do Not Delay!

Table 1: Total US military firearms, by service, 2001

Air Force	260,000*
Army	1,608,000
Coast Guard	20,268
Navy (includes Marines)	800,000*
Total	**2,688,268**
Total firearms per uniformed member	**1.05**

*Estimated
Source: *Small Arms Survey 2002*, Table 2.12

- All legacy parts require a UID by Dec 31, 2010,
- This will require that starting on May 12, 2005 at least 1306 firearms be marked daily to meet the quota. Every day delayed only increases this number!

The Symbology Research Center is the most advanced 2-D symbology R&D laboratory in the world, maintaining the countries most comprehensive materials marking database. The center maintains a close relationship with NASA to further develop this 2-D technology. The SRC, through RVSI, holds more than a hundred patents related to 2-D and 3-D technology and has developed, enhanced and tested over 40 compressed symbology marking methods.

Our consulting service can usually solve your most difficult machine-readable part marking or code reading problems via the use of the Data Matrix symbology. Any government or commercial entity can request assistance on a specific product identification problem by submitting a Problem Statement to RVSI Corporate Headquarters 486 Amherst St, Nashua, N.H. 03063 1(800) 468-9503.

RVSI Acuity CiMatrix

Symbology Research Center

5000 Bradford Drive NW
Suite A
Huntsville, Alabama 35805
Tel: (256) 830-8123
Fax: (256) 895-0585

Web Sites:
www.UIDSupport.com
www.rvsi.com

E-mail:
UIDinfo@UIDSupport.com

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